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Diagnostic Accuracy of Multi-Slice Computed Tomographic (MSCT) Angiography in the Detection of Cerebral Aneurysms

Background/Objective: Multislice computed tomographic (MSCT) angiography is a rapid and minimally invasive method for the detection of intracranial aneurysms. The purpose of this study was to compare MSCT angiography with digital subtraction angiography (DSA) in the diagnosis of cerebral aneurysms.

Patients and Methods: In this cross sectional study we evaluated 111 consecutive patients [42(37.8%) male and 69(62.2%) female], who were admitted under clinical symptoms and signs, suggestive of harboring an intracranial aneurysm by using a four detector MSCT angiography. Then we compared results of MSCT angiography with DSA results as a gold standard method. DSA was performed by bilateral selective common carotid artery injections and either unilateral or bilateral vertebral artery injections, as necessary. MSCT angiography images were interpreted by one radiologist and DSA was performed by another radiologist who was blinded to the interpretation of the MSCT angiograms.

Results: The mean±SD age of the patients was 49.1±13.6 years (range: 12-84 years). We performed MSCT in 111 and DSA in 85 patients. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive and negative likelihood ratio (LR) of MSCT angiography, when compared with DSA as the gold standard, were 100%, 90%, 87.5%, 100%, 10 and 0, respectively.

Conclusion: MSCT angiography seems to be an accurate and non-invasive imaging modality in the diagnosis of intracranial aneurysms.

Keywords: Intracranial Aneurysm, Subarachnoid Hemorrhage, Computed Tomography, Digital Subtraction Angiography

Introduction

Subarachnoid hemorrhage (SAH) due to ruptured aneurysms kills more than 10000 patients in North America annually.[1]

Fast and accurate evaluation of the patients is very important in the management and planning of the therapeutic interventions. Digital subtraction angiography (DSA) is currently the accepted gold standard method for the detection and characterization of intracranial aneurysms. DSA is an invasive test; however, results from studies of patients who had SAH and underwent cerebral DSA indicate a 0.07%-0.5% risk of permanent neurological complications.[2] Besides, this method is time consuming and expensive.[3] DSA has high sensitivity and specificity values in the detection of cerebral aneurysms while false negative results range from 5% to 10%.[4]

The false negative rate is generally due not to limitations of spatial resolution but to some limitations of angiographic equipment that make it difficult to obtain the optimal projection necessary to identify some aneurysms.[5,6] In some cases, one leading cause to false negative results is the impossiblity to know which specific projection will render an aneurysm visible.[6,7]

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Furthermore, accurate detection and measurement of the aneurysm neck and its relationship to the parent artery may be difficult or impossible which impair the suitable treatment method.[7]

Helical CT angiography is a noninvasive imaging method. Images can be relatively safely obtained and there is no need for arterial puncture or catheter insertion.

Cerebral CT angiography has been widely used in the diagnosis of intracranial aneurysms and this method does not carry the neurological risks of DSA. Furthermore, it is less expensive and quicker than DSA.[8-11]

Multi-section CT scanners are better than single section CT scanners due to faster speed, longer distance and better section thickness.[12,13]

The purpose of this study was to compare MSCT angiography with DSA in the detection of cerebral aneurysms.

Patients and Methods

MSCT angiography was obtained in 111 consecutive adult patients evaluated in a referral university affiliated hospital from February 2006 to March 2007.

Patients were admitted under clinical symptoms and signs suggestive of harboring an intracranial aneurysm (acute headache, nausea, vomiting, or stiff neck) and all of them had non-traumatic SAH according to brain CT scan or lumbar puncture. The Glasgow Coma Scale (GCS) of our patients was in the range of 11-14. Inclusion criteria were the performance of both MSCT angiography and DSA studies, or surgical results. Informed consent was obtained from all patients. We did not perform DSA only for the purpose of the present study.

The MSCT angiography examinations were performed with a four detector row CT unit (Multislice, GE-USA) based on a standardized protocol. The MSCT angiographic data acquisition itself was done according to the following protocol: spiral mode 0.7 second slices, four row collimation at 1.25 mm, pitch 0.75, reconstruction interval 0.6 mm, and acquisition parameters 120 KVP/240MA. A caudo-cranial scanning direction was selected covering the volume extending from 1cm below the foramen magnum to the top of the frontal sinuses. By using a 20 gauge needle, we injected 100 cc of contrast media (Omnipaque® 240) via an antecubital vein with 4 cc per second speed. All CT images were diagnostic and there were no technical failures or complications during scanning. (Fig. 1)

Reconstructions were done on a workstation, by using MIP (Maximum Intensity Projection), VR (Volume Rendering), MPR (Multi Plannar Reformat), and curved plannar methods for axial basic images. The window level and window width were 300-50 and 2000-200, respectively.

Standard four-vessel angiography of the brain with DSA biplane system was done via a transfemoral approach (Biplane DSA/ integris v-3000 /Philips medical systems /Netherlands) with a matrix of 1,024 ×1,024 pixels and kv equal to 45-125.

DSA was carried out with bilateral selective common carotid artery injections and either unilateral or bilateral vertebral artery injections, as necessary.

At first, we reviewed the axial images for any gross abnormality, and then we used different 2D reformats on the workstation for further evaluation. When we noted a suspicious lesion, we correlated it with axial images and then we used volume rendering software to confirm the pathology.

Injections were performed by a power injector. We used the bolus triggering method and placed trigger ROI (region of interest) on the aortic arch.

MSCT angiography images were interpreted by one radiologist and DSA was studied by another radiologist who was blinded to the interpretation of the MSCT angiograms.

Both of them were experted in neuroradiology and they had been working in the neuroradiology and angiography department for at least ten years.

Then we compared the results of MSCT angiography with DSA results as the gold standard method.

Once again, in patients who underwent surgery, we compared MSCT angiography results with surgery as the gold standard method (n=51) and in cases that did not undergo surgery, DSA results were considered as the gold standard (n=60) and statistical analysis was done.

The maximum interval between MSCT and DSA or surgery was three weeks.

Ethics review board approval of our university was obtained for this study.

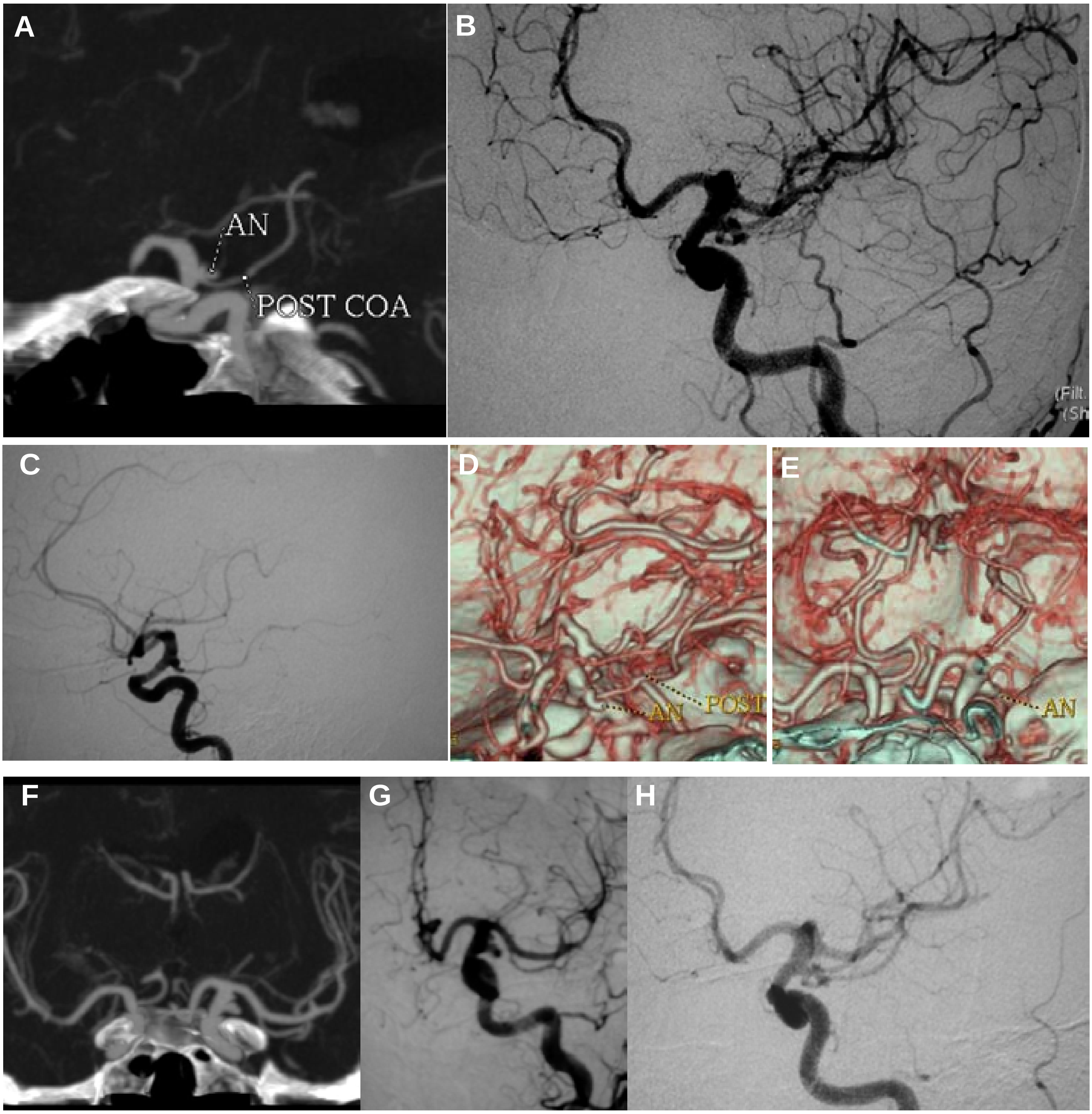

Fig. 1. 50-year-old woman with SAH.
A. CTA: Sagital MIP view of left internal carotid artery shows a small aneurysm near orifice of posterior communicating artery.
B. DSA: Lateral oblique view of left internal carotid artery shows difficulty in diagnosis of such a small aneurysm by DSA.
C. DSA: Lateral view of left internal carotid artery shows small aneurysm near orifice of posterior communicating artery.
D. CTA: VR view of posterior communicating artery shows the aneurysm.
E. CTA: VR cononal view of internal cariotid artery shows the aneurysm.
F. CTA: MIP coronal view better demonstration of posterior communicating artery orifice aneurysm.
G. CTA: Shows small aneurysm near the orifice of left posterior communicating artery.
H. DSA: Oblique view of left common carotid artery infusion cannot show the aneurysm properly.

Sensitivity, specificity, positive likelihood ratio (LR) and negative LR indices were used for the evaluation of accuracy. We also measured the negative predictive value (NPV) and the positive predictive value

Table 1. Accuracy and Predictive Value Statistics of MSCT Angiography for Detection of Cerebral Aneurysms in Comparison with DSA

Aneurysms in MSCT-A	Presence of Aneurysms in DSA		Total
	Yes	No	
Yes	35	5	40
No	0	45	45
Total	35	50	85

Sensitivity [CI 95%]: 100% [87.7%-100%]
Specificity [CI 95%]: 90% [77.4%-96.3%]
Positive Likelihood Ratio [CI 95%]: 10 [4.4-23]
Negative Likelihood Ratio [CI 95%]: 0 [0–N/A]
Positive Predictive Value [CI 95%]: 87.5% [72%-95.3%]
Negative Predictive Value [CI 95%]: 100% [90.2%-100%]

Table 2. Accuracy and Predictive Value Statistics of MSCT Angiography for Detection of Cerebral Aneurysms in Comparison with Surgery and DSA

Aneurysms in MSCT-A	Presence of Aneurysms in Surgery and DSA		Total
	Yes	No	
Yes	58	1	59
No	1	49	50
Total	59	50	109

Sensitivity [CI 95%]: 98.3% [89.7%-99.9%]
Specificity [CI 95%]: 98% [88%-99.9%]
Positive Likelihood Ratio [CI 95%]: 49.15 [7.05–342.22]
Negative Likelihood Ratio [CI 95%]: 0.02 [0.00–0.12]
Positive Predictive Value [CI 95%]: 98.3% [89.7%-99.9%]
Negative Predictive Value [CI95%]: 98% [88% - 99.9%]

(PPV) in our study.

A likelihood ratio greater than 10 is suggestive of large and often conclusive increase in the likelihood of the disease and a likelihood ratio less than 0.1 is suggestive of large and often conclusive decrease in the likelihood of the disease.

Results

The mean ±SD age of our patients was 49.1±13.6 years (range: 12-84 years). In this study 42 patients (37.8%) were male and 69(62.2%) were female. The median ±SD maximum diameter of aneurysms (in a two-dimensional view) was 6.8 ±11.5 mm. The smallest diameter measured by MSCT was 1.40 mm.

We detected aneurysms in 60 out of 111 patients (54.1%) in MSCT angiography.

Among these, 26 patients underwent surgery without a DSA study.

Among the 85 patients who underwent DSA, an aneurysm was seen in 35 patients (41.2%) and 50 of the patients (58.8%) had no aneurysm. In the 51 cases who underwent surgery, 45 of them (88.2%) had at least one aneurysm. Six patients had no evidence of aneurysm in surgery. In these patients, surgery was performed because of other causes, such as removing brain tumors, foreign bodies and other reasons.

We recorded the number of aneurysms in our patients and found single aneurysms in 45, two aneurysms in 7, three aneurysms in 2 and four aneurysms in 6 patients. In addition, 47 of the patients had malformations of the circle of Willis.

The most common site of the aneurysms was the middle cerebral artery (38%). The aneurysms were seen in the anterior communicating artery, internal carotid artery, anterior cerebral artery, common carotid artery, and basilar artery in 33%, 14%, 2%, 2%, and 2%, respectively.

The results of accuracy statistics and predictive values of MSCT angiography in comparison to two gold standards and their estimated 95% confidence interval are shown in Tables 1 & 2.

The point estimations for sensitivity, specificity, PPV, NPV, positive and negative LRs of MSCT compared with DSA, were 100%, 90%, 87.5%, 100%, 10 and 0, respectively (Table 1).

When we considered the surgery findings together with DSA results as the gold standard, the point estimations of sensitivity, specificity, PPV, NPV, positive and negative LR of MSCT were 98.3, 98%, 98.3%, 98%, 49.15 and 0.02, respectively (Table 2).

Discussion

Incidence of intracranial aneurysms was reported between 1 to 7 percent in the literature.[14,15]

More than 80% of symptomatic intracranial aneurysms present with SAH.

Rupture of these aneurysms are accompanied by high mortality and morbidity rates. Early diagnosis is very important and vital for surgical or endovascular therapy.

CT angiography is a noninvasive and quick method for the diagnosis of intracranial aneurysms. Introduction of multi-section CT scanners is one important advance in CT angiography.

According to different studies in the literature, the sensitivity of CT angiography in the diagnosis of intracranial aneurysms ranges between 67% to 100% and the specificity ranges between 50% to 100%.[14,16-

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Reconstruction of three dimensional angiography images in any desired plane or angle is one important advantage for CT angiography.[14]

By using multiple projections obtained in CT angiography, better evaluation of size, neck, orientation and relationship with the surrounding structures is possible.[14,20-22]

One important additional information for surgical intervention is the association between the aneurysm and its surrounding bony structure like the skull base, sella turcica or clinoid process and also the aneurysm neck size, aneurysm top orientation, the arterial branch near or inside the aneurysm and the peripheral thrombosis, which is possible by using CT angiography.[23,24]

The sensitivity and specificity of MSCT angiography in our study were similar to many other studies.[2,25]

In the Uysal et al. study that was published in 2005, the sensitivity and specificity of MSCT angiography in the detection of intracranial aneurysms were 97% and 100%, respectively that was higher than our results.[14]

DSA is the gold standard imaging modality for the diagnosis of aneurysms.[14]

Surgery shows real findings in these patients; therefore, it has a higher value than DSA in the detection of these lesions. As a result, the combination of DSA and surgery is more reliable than DSA alone.

In patients who underwent surgery, we used surgical results as the gold standard; otherwise, DSA was the gold standard method. Consequently, we found that true positive results were higher and false positives were lower than DSA alone.

This means that the specificity and positive LRs increased by using a better gold standard method, because of the ability of MSCT to show smaller sized aneurysms by using different projections.

The NPV of MSCT in comparison to DSA was 100% in our study.

In this study, we measured the likelihood ratios of MSCT angiography in the diagnosis of intracranial aneurysms (previous studies did not measure this ratio) and found that this method is a valid test for the detection of intracranial aneurysms.

One limitation of this study was the fact that we did not evaluate the sensitivity and specificity of MSCT angiography according to the size of the aneurysms. Another limitation of our study was that not all patients who had multi-section CT angiography underwent digital subtraction angiography.

Finally, MSCT angiography is safe and non-invasive and seems to be a valid test in detecting intracranial aneurysms.

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